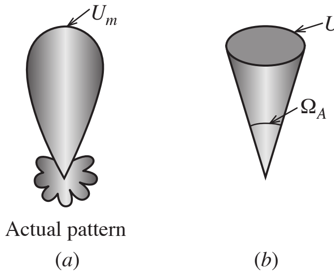


Figure 2-13 Antenna beam solid angle Ω_A. (a) Plot of radiation intensity $U(\theta, \phi)$ from an actual antenna. (b) Plot of radiation intensity with all radiation from the actual antenna concentrated into a cone of solid angle Ω_A with constant radiation intensity equal to the maximum of the actual pattern.

This also follows from (2-134) and (2-142). Finally, substituting (2-135) in (2-140) along with (2-142) gives

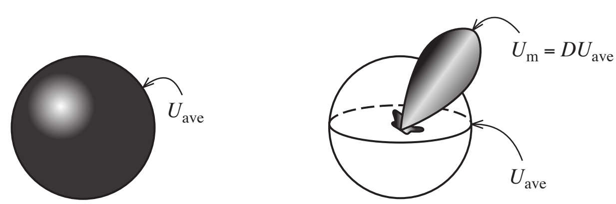
$$\boxed{D = \frac{4\pi}{\Omega_A}} \qquad \text{directivity} \tag{2-144}$$

These results show that directivity is entirely determined by the pattern shape; it is independent of the details of the antenna hardware. Directivity as a function of pattern angle is expressed simply as the directivity multiplied by the power pattern:

$$D(\theta, \phi) = D|F(\theta, \phi)|^2 \tag{2-145}$$

Since $|F(\theta, \phi)|^2$ has a maximum value of unity, the maximum value of directivity as a function of angle is D.

The concept of directivity is illustrated in Fig. 2-14. If the radiated power were distributed isotropically over all of space, the radiation intensity would have a maximum value equal to its average value as shown in Fig. 2-14a, that is, $U_m = U_{ave}$ or $\Omega_A = 4\pi$. Thus, the directivity of this isotropic pattern is unity. The distribution of radiation intensity $U(\theta, \phi)$ for an actual antenna is shown in Fig. 2-14b. It has a maximum radiation intensity in the direction $(\theta_{max}, \phi_{max})$ of $U_m = DU_{ave}$ and an average radiation intensity of $U_{ave} = P/4\pi$. There is D times as much power density in the direction $(\theta_{max}, \phi_{max})$ as there would be if the same total power were radiated by an isotropic source. Thus, by directing the radiated power P in a preferred direction (the maximum radiation direction) the radiation intensity is increased in that direction by a factor of D over what it would be if the same radiated power had been isotropically radiated.



(a) Radiation intensity distributed isotropically.

(b) Radiation intensity from an actual antenna.

Figure 2-14 Illustration of directivity.